The Theatre Broadcast System

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ABSTRACT

The Theatre Broadcast System is a DSTO developed Concept Technology Demonstator communications system comprising a high data rate satellite broadcast capability matched with low/medium data rate request channels. The system has the potential to enhance the effectiveness of data dissemination to deployed forces in a cost effective manner. This document provides an overview of the system concept, the principles of operation and details of the initial implementation.

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The Theatre Broadcast System

Executive Summary

The Theatre Broadcast System (TBS) is a demonstration high bandwidth, tactical information delivery system developed by DSTO Communications Division. It is targeted at operations on the forthcoming Optus C1 satellite. The concept consists of uplinking ADF data, and both audio and video information, from an injection point. Users in the field receive the broadcast using a half metre diameter dish connected to a compact receive suite and laptop running Windows NT. Low bandwidth communications may be used to request information to be broadcast. User interfaces consist of standard PC applications such as web browsers, mail clients, in addition to any specialised applications required for user data display. The receive terminals may be operated stand-alone or connected to a local area network. DSTO has engineered a COTS-based hardware solution, developed an extensive software architecture and applied military grade security.

Contents

1. Introduction

Recent developments in satellite TV technology have made high bandwidth, military information delivery systems realisable using compact, inexpensive, consumer devices. Commercial broadcast and VSAT (Very Small Aperture Terminals) architectures can be readily adapted to military needs provided security architectures and appropriate software can be developed. Such systems are made possible by new generations of satellites which offer the power and bandwidth to deliver broadband multimedia to receiver dishes as small as eighteen inches in diameter. Traditional military satellite communications systems on the other hand, are often expensive, bulky, depart from commercial standards and require extended system design and fabrication programs. In many cases, it makes sense to forego traditional approaches to gain the benefits of the latest technology, particularly for non-critical and augmented communications. Indeed, there is a world wide trend towards the use of commercial-type communications to support military forces. Ruggedised military satellites incorporating processing transponders and beam forming antennas mated with over dimensioned receive systems and spread spectrum receivers can be retained for critical command and control traffic if needed.

The Theatre Broadcast System (TBS) is a military application of commercial satellite broadcast technology designed specifically for Australian Defence Force requirements. It aims at delivering data, audio and video to many widely distributed users, by direct service to stand alone terminals, and by feeding deployed communications systems such as local data archives and LANs. It relies on COTS hardware, adapted to support military grade encryption, and an extensive, custom software architecture designed for Australian military requirements.

Broadcast communication systems have a number of advantages over their full duplex counterparts. Broadcast systems can simultaneously service a large number (hundreds) of receive terminals from a single broadcast hub using a fixed transponder bandwidth. Receive terminal costs are generally much lower than that required for full duplex systems, as expensive transmit hardware is avoided. In addition, terminals may receive transmissions whilst maintaining local radio silence. Data required by all receivers need only be transmitted once, and the resultant efficiency gain can be enormous in many applications. By comparison, use of full duplex links requires transponder bandwidth, and therefore cost, to increase linearly with the number of receivers. Each terminal must be capable of transmission, and it is usually not possible to maintain radio silence without breaking the reception path.

The prime disadvantage of broadcast systems however, is that many protocols and service types (for example the Internet Transmission Control Protocol, TCP) cannot be supported over one way links because they rely on an explicit return path. This is a severe limitation. Pure broadcast systems offer no means for the remote user to acknowledge receipt of traffic, to modify the broadcast they receive, or to request additional information. This often precludes their use for command and control traffic.

Considerable research is currently being devoted to addressing these problems whilst maintaining the advantages of a broadcast environment. If a wide band broadcast is teamed with a narrow band request link or back-channel, a flexible system can be designed to service inherently asymmetric traffic. If the back-channel is connected permanently, or at least occasionally, many features of the full duplex link are regained. Receipt of information can be acknowledged, retransmission of data received in error may be requested, the broadcast can be customised by users to suit local requirements and limited information (such as simple messaging) transmitted into the hub station. Asymmetric systems excel in situations where upstream traffic is minimal but high downlink bandwidth is required. These aspects are summarised in Table 1.

An example of a modern asymmetric communications system is a Pay-per-View satellite TV architecture. Movies are received via the broadcast downlink at 2 Mbps, and a 2400 bps telephone link, integrated into the set top box, is used for movie selection, authentication and billing. Another example is that of "asymmetric Internet extension" over satellite. The broadcast downlink and phone back-link are connected to a personal computer producing a system which offers excellent web browsing performance. Proxies direct the low bandwidth upstream traffic from the user (icon clicks) via the phone line, and deliver internet content over the broadcast satellite. The TBS system is an example of this asymmetric Internet extension technology.

2. *The Concept of Military Broadcast*

The principal task of Theatre Broadcast is to deliver situational awareness to deployed forces through provision of high bandwidth information tailored to the specific requirements of individual receiving locations. Information resident in the strategic domain (Figure 1) can be transferred to users using both PUSH and PULL concepts. A strategic commander or broadcast manager can direct that information products (video, audio or data) be broadcast, or PUSHed, from the broadcast centre or Primary Injection Point (PIP), to deployed users. This can be done on a case by case basis, or by an automated, repetitive process. The effectiveness of this approach is dependent on the extent to which user needs can be anticipated, the extent of preplanning and on the judgement of strategic commanders in response to changed tactical user requirements. It is clearly appropriate for delivering situational awareness maps showing force movements and locations for example, which can be broadcast every few minutes to all forces in theatre.

Not all needs can be anticipated however, and the PULL capability allows users to request the unplanned broadcast of specific information (Figure 1). The simplest PULL method uses manual voice or email connectivity to Request Manager personnel, over any available links, to request transmissions. This is time consuming and labour intensive. Automated PULL concepts such a web browsing, database retrievals and data mining are more attractive. Here, Request Link communications are used to make a data connection to Request Manager software agents

Feature	FDX	BC	Asym
Simultaneous service to many receivers	No	Yes	Yes
Terminal cost	High	Low	Low
Radio silence possible while receiving	No	Yes	Yes
Support TCP	Yes	No	Poss.
Support UDP	Yes	Yes	Yes
Can acknowledge receipt	Yes	No	Yes
Retransmission of errored packets possible	Yes	No	Yes
Upstream information transfer, e.g. messaging	Yes	No	Some

Table 1. *Some features of pure broadcast (BC), full duplex (FDX) and asymmetric (Asym) communications systems.*

and request broadcast of information from source archives in real time. The HTTP (web) protocol is ideal for this task as it performs well over highly asymmetric links and is widely implemented in commercial systems. Many database engines for example, support web based access.

Information derived from sources in the theatre can be injected into the system either by trunking back to the Primary Injection Point (as shown in Figure 1) or by direct uplink to the broadcast satellite. The location managing these data transfers is known as a Tactical Injection Point (TIP).

Information broadcast from the PIP is, in general, received by all units. Security architectures are an important aspect of broadcast systems in that they are the sole means of access control. Conventional bulk hardware encryption or software encryption schemes can provide separate security compartments. Flexible hardware capable of payload encryption of many simultaneous IP and/or ATM streams is becoming increasingly available.

The large volume of information delivered by high data rate broadcast systems must be carefully managed to avoid overload of both users and physical storage systems. This can be achieved using a combination of customised user profiles and intelligent caching. Accessing information resident in cache is very convenient for the user. It is available immediately if

required (no delay), request links do not need to be connected and operations can proceed during radio silence. Alternatively, the information can be accessed at a later time, for example over night broadcast for morning analysis. Cache searching efficiency can be enhanced by provision of local pointers or links broadcast with the information. A user defined local profile can specify the nature of information which is of interest, by location, keyword, time, etc. All received information is initially cached by the receiver terminal, but after the cache is filled, information not matching the profile is preferentially discarded. Eventually, some information matching the profile may also need to be discarded, again based on specific criteria. Large caches (many gigabytes) are desirable.

This information management regime is difficult to implement comprehensively today. For effective cache and profile management, all information must be tagged in a common metadata format specifying attributes such as information type, pertinent location, expiry time, etc. This metadata is used by management algorithms to implement the user profiles. Unfortunately, this is rarely the case in current military data systems. Nevertheless, some management control can be obtained using tags implemented within the broadcast system to represent different data classes, concurrent use of differing metadata formats from different information repositories and application of simple principles such as discarding older information first.

3. TBS Hardware Architecture

(a) Transmit Suite

The TBS hardware architecture designed by DSTO Communications Division derives from that used for commercial digital satellite TV (HDTV) broadcast and conforms to the MPEG-2 (Motion Picture Experts Group) and DVB (Digital Video Broadcast) standards. While it may be possible to develop more appropriate devices, use of commercial standards offers inexpensive, highly integrated components, the opportunity to field a demonstration system on a short time scale and the possibility of integrating military information broadcasts seamlessly with commercial TV broadcasts should military satellites be unavailable.

A simplified version of the TBS transmit architecture is shown in Figure 2. Analogue video and audio, either direct from a camera and microphone, or trunked from another location, enter the encoder and are digitised, compressed and framed into packets by standard MPEG-2 algorithms. Incoming IP (UDP) data is converted into a serial stream using a network bridge ("B" in the figure) and encoded into MPEG-2 packets. The encoder output consists of a stream of MPEG-2 transport layer packets, some containing audio, some video and some data information. This stream is then encrypted and passed to a repacketiser, which reframes the raw encrypted serial data into an MPEG-2 transport stream. Stream data from different security compartments is then combined in a DVB MUX before modulation, upconversion and uplinking to the satellite from the PIP. QPSK modulation with a FEC comprising a rate ¾ Viterbi code and a 204/188 Reed Solomon code are typically used. Ku-band transponders have

been used for system trials to date, however the Ka-band payload on the Optus C1 satellite will ultimately be used for Australian Defence high data rate broadcasts.

(b) Practical Details - MPEG, DVB and Overhead

Each 188 byte MPEG-2 transport stream packet incorporates a 4 byte header containing the important Program Identifier (PID) information, which identifies each packet as containing data from a particular information stream. For example, the video data for a TV program and the corresponding English and Spanish audio data would each have different PID values. IP data is likewise encoded with a specific PID. The MPEG encoders used in the system described here are each capable of simultaneously encoding: a video program at compressed output rates up to 8.2 Mbps, four audio channels at compressed output rates up to 256 kbps (usually used as two stereo pairs), a high bit rate data stream at input rates up to 10 Mbps and a low bit rate data stream at rates up to 57,600 bps. The low bit rate data is used commercially to provide teletext service onto the video picture.

Additional MPEG-2 transport stream packets containing program associations (a list of all programs in the stream), program maps (specifying which audio or teletext PIDs associate with which video PIDs), and conditional access tables (commercial encryption) are also produced by the encoder. Further packets may optionally be produced giving physical system configuration information, service descriptions (names of networks and providers), groups of services, running status (whether or not a particular event is in progress) and current time and date. The format of these additional tables is specified by the Digital Video Broadcast (DVB) standard.

It can be shown that the total output data rate of the MPEG-2 encoder is given by:

$$
\begin{aligned}
OutputRate = {} & \frac{188}{184}\left(Video + 160 \times Pic\right) \\
& + \frac{188}{184}\left(Audio\right) \\
& + \frac{188}{184}\left(\left(LSD + HSD\right) \times 1.01\right) \\
& + PAT + PMT + PCR \\
& + DVB
\end{aligned}
$$

where $Video$, $Audio$, LSD and HSD are the data rates assigned to the video, audio, low speed data and high speed data services respectively; Pic is the video picture (frame) rate; PAT, PMT and PCR are the MPEG-2 tables referred to above; and DVB represents the optional DVB tables. The factor 188/184 represents the packet header overhead.

Assuming no DVB tables are transmitted, as is the case for TBS, the resultant overhead is primarily a result of the $PAT + PMT + PCR$ term, which evaluates to approximately 135 kbps. This represents a minor fractional overhead at the usual operating rates of >2 Mbps, however it can become significant if low output rates are used.
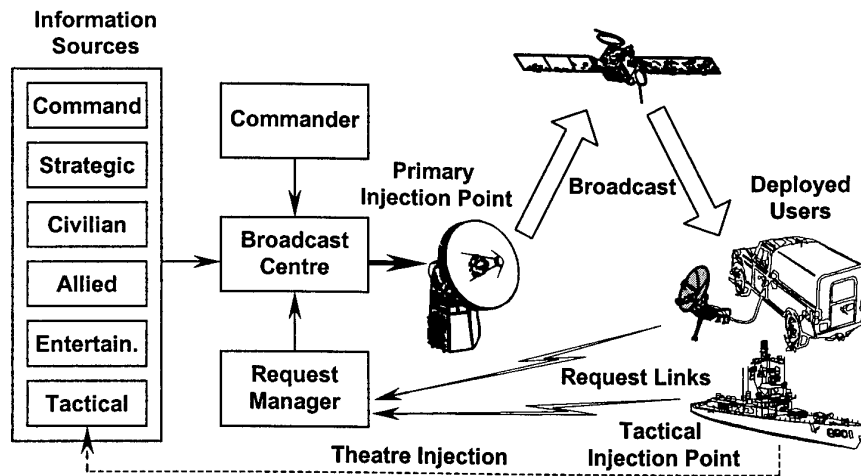
Figure 1. *The concept of Theatre Broadcast involves both command PUSH of information to users over the broadcast link and user PULL of information from strategic archives using request links.*
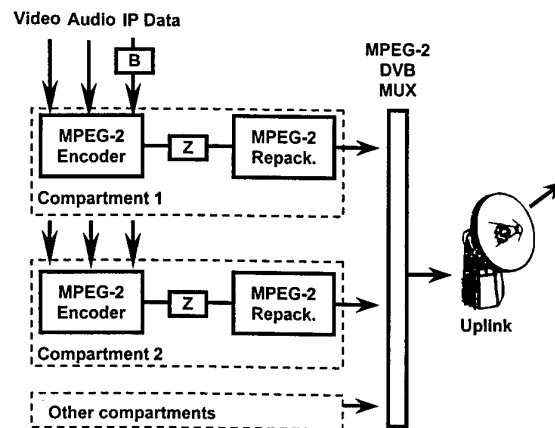

Figure 2. *The Theatre Broadcast transmit architecture maintains compatibility with commercial MPEG-2/DVB systems whilst implementing military grade security. To date only a single compartment has been constructed.*
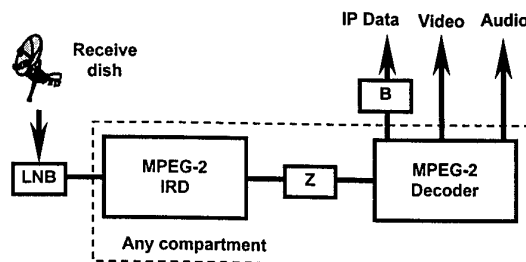

Figure 3. *The Theatre Broadcast receive architecture makes use of compact, inexpensive Integrated Receiver Decoders The equipment can receive any compartment which can be decrypted.*

(c) Receive Hardware

The receive architecture uses a 0.6 metre diameter dish feeding an LNB (low noise block down converter) which down-converts the signal from Ku-band to an L-band intermediate frequency (Figure 3). The IF is then fed to an Integrated Receiver Decoder (IRD) which demodulates the signal, performs error correction, and decodes the MPEG-2 transport stream, outputting the packet payloads as a serial data stream. The decoder is configured to output data corresponding to the PID of the security compartment desired. The data is then decrypted and input to a second IRD which is configured to perform the MPEG decode function only; the receiver and demodulator functions are disabled. Analog video and audio are output directly to display devices and speakers, and serial data converted to IP packets using a network bridge. A ruggedised notebook computer running Windows NT is typically used as the receive client, receiving the broadcast on an IP interface, other LAN based hosts accessing broadcast information resident on this computer via a second IP interface. Alternatively, the broadcast can be routed directly onto a local LAN.

The current TBS compact, transportable receive suite configuration is packaged in two waterproof cases 80×70×38 cm and 80×55×70 cm, which includes (IRDs), the dish, cabling, Mobilesat request link hardware, a small TV, a printer, and other accessories (Figures 4 and 5).

(d) Request Links

Request links are best matched to the requirements of the deployment. Some deployments need voice links only, some require minimal data links to be connected occasionally, and others require medium data rate permanent connections. Some practical request link classes are shown in Table 2. Voice connectivity represents the minimal, non-automated link to the broadcast centre allowing manual requests to be made of manning staff. Automated request links are implemented via an IP interface (either direct or through a encrypted serial port) on the receive client. Any communications medium capable of supporting TCP is satisfactory. The most technically interesting request link category is that of data services carried on commercial voice networks. These include terrestrial PSTN, GSM and CDMA as well as LEO and GEO satellite networks such as Iridium, Mobilesat, DMCN, Globalstar, ICO, etc. While these networks are designed and marketed for voice, they all support data connections at various rates in the 2.4-16 kbps range. In the future, such services will be ubiquitous and inexpensive. Security solutions which dispense with external

Request Link Category	Typical BW
Voice (manual)	3 kHz
Data on commercial voice network	2.4-16 kbps
Transmit to broadcast satellite	64 kbps
Trunked data network	>1 Mbps

Table 2. Typical request links used in the TBS system.

Figure 4. The standard TBS compact receive suite configuration uses a 0.6 m dish, a small electronics rack and a laptop computer.
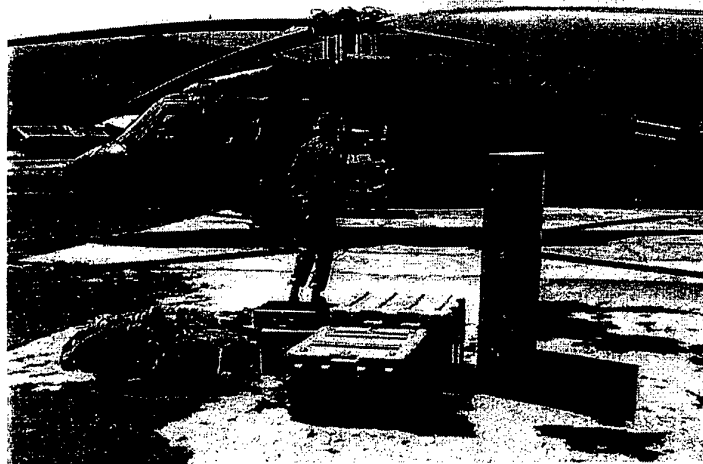
Figure 5. TBS standard receive suite packaging consists of two ruggedised containers, the receive electronics (centre front) and the accessories box (centre rear).

hardware cryptos are under development. Because of these inherent advantages, they have received the most attention in the development of request links for TBS, and specific hardware interfaces developed for PSTN, GSM and Optus Mobilesat. Enhanced request channels are implemented for larger platforms such as ships by creating an additional full duplex link to the PIP through the broadcast satellite with the same dish used to receive the downlink. This typically requires increasing the dish size from the standard 0.6 m to approximately 1.2 m diameter (at Ku-band) to avoid spillover onto adjacent satellites. A 64 kbps request link is typically used. Finally, trunked, secured data networks, implemented via fixed line or satellite, often exist at major installations such as deployed headquarters or fixed bases. These can be used directly as TBS request links.

4. Software Architecture

(a) TBS File Delivery

The TBS software architecture consists of software applications running on a scheduled file delivery service. The applications perform user driven tasks such as email, web browsing, etc, while the delivery service provides the connectivity required to transparently support the applications. Reliable file delivery can be attempted if request links are connected, either in real or delayed time.

File delivery over a broadcast system differs from file delivery over a conventional network in two principal ways: data is delivered simultaneously to multiple recipients and the return path may be absent. The Internet Protocol (IP) incorporates a multicast mechanism, which directs IP Datagram traffic to specified users. IP multicast is used by TBS for data transmissions over the broadcast channel. Multicast offers the opportunity to screen traffic from users or target specific users via their IP address, although this feature has not been used to date. The standard TCP protocol requires a full duplex path along which to acknowledge received packets and to request retransmission of packets received in error. In contrast, the User Datagram Protocol (UDP), a connectionless protocol which makes no attempt to establish a path to the sender, sends no replies and no requests for retransmission is a natural choice for broadcast systems.

To address the issue of errored transmissions within the TBS architecture DSTO developed a flexible, proprietary file transmission protocol, known as MUSTAFA.MUSTAFA supports UDP/IP multicast to transmit files at bandwidths specified by a real time adaptive scheduler known as RATS. The MUSTAFA server process breaks data files into appropriately sized packets and multicasts them over the broadcast channel to client MUSTAFA processes which reconstruct the file onto the host's file system (Figure 6). The MUSTAFA program attempts reliable file delivery in the presence of channel errors through a three pronged strategy. First, multiple transmissions of each file are made, which allows packet-wise file reassembly by the receive clients, except if a particular packet is errored in all transmissions. Two file transmissions are usually used. Second, if a back link is currently available, MUSTAFA can accept packet acknowledgements allowing

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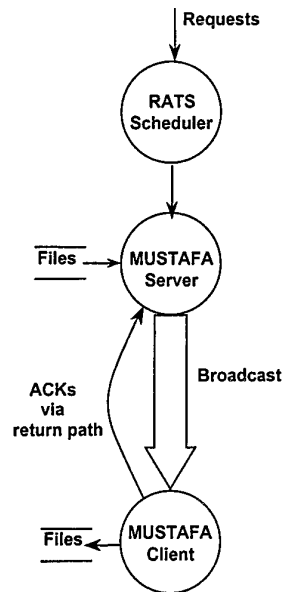
Figure 6. Schematic operation of the TBS file transfer process.

errored packets to be immediately scheduled for retransmission. Hosts without connected back links benefit from retransmissions requested by others if corresponding corruptions have occurred. Thirdly, an additional feature known as "Delayed Gratification", allows errored packets from large files to be retransmitted when a back link is reconnected at a later time (possibly days later) and file reassembly on the client completed. This procedure was found desirable to improve service to files in the 100MB-1GB size range. The effectiveness of this latter strategy is largely dependent on the availability of cache space at the client. In addition, MUSTAFA can transmit IP streams (as opposed to files) at specific data rates, and is able to control the stream transmission rates. MUSTAFA can notify stream sources to change their output data rate, assuming flexible source encoding is available.

The RATS scheduler optimizes use of the broadcast channel by calculating the bandwidth to be applied to all current broadcast requests, forming a schedule, and controlling multiple, simultaneous transfer processes within MUSTAFA in real time. In addition, requests for retransmission of errored packets from multiple users are fielded, processed and the packets added to the schedule. The scheduler's algorithm processes three priority metrics supplied for each request, to determine a mix of concurrent broadcast items which delivers the maximum military value at a given instant of time. These are the military priority class of the traffic which determines the time in which the data must be delivered, the user perceived value of the request and the action requested if RATS is unable to satisfy the request in the time specified. The latter comprises three options, discard the request, proceed with transmission if the data is not going to be "too" late and transmit regardless of arrival time.

The concept of "military value" is fundamental to system operation. A specific definition of this quantity incorporating the amount of information delivered, delivery times, importance and other parameters of the traffic has been developed.

The concepts behind and operation of the RATS algorithm are complex, and are discussed elsewhere. All access to the broadcast channel is negotiated through the scheduler by lodging a request. Each request specifies the user's requirement (file to be transmitted), authentication details of the requester, and the desired scheduling parameters. The scheduler determines if the request is to be serviced immediately, and if so submits the job to MUSTAFA specifying the bandwidth allocation. The schedule is constantly recalculated (approximately every second, according to a configuration parameter) to take account of delivery progress on existing jobs and newly received requests, and the results forwarded to MUSTAFA for implementation. The effective bandwidth of any broadcast job is constantly adjusted to meet the optimization objective.

The system described is superior to simple scheduling queues in that the military value delivered (judged by the definition used) remains high, even under severe system overload conditions. This is considered important in the Australian context, where limited satellite resources, lower data rates and smaller dishes are expected, than for example, is the case with the US GBS system.

Typical hardware required at the broadcast centre consists of a Sun workstation running the RATS scheduler and a high end PC running Windows NT supporting MUSTAFA. This machine also runs the server components of many of the delivery applications discussed below.

(b) Application Delivery over TBS

(i) Automated File Delivery

The most fundamental application running over TBS is the TBS PUSH Service, which offers automated, periodic retransmission of specified information. New information is continually becoming available at the broadcast centre, and this service is used to ensure that data in the receive terminals is constantly updated to accurately reflect that at the server.

Primary uses of the service are to deliver rapidly changing information such as track data and mail databases, and to download large numbers of associated files such as archive directories or web site mirrors. Critical system configuration parameters required by all receivers are also transmitted automatically. Automated updates require no action by users, and can be delivered overnight or during down time between operations, in the absence of receiver manning personnel. Repeated transmissions also allow terminals which have been out of service due to shutdowns for transportation, hardware failures, or have been out of the satellite coverage area, to be rapidly and automatically updated upon requiring the system. Multiple transmissions also maximise the chance of information delivery in the presence of channel errors and jamming. A graphical user interface to the program allows a broadcast manager to specify files and directories grouped into logical categories having common characteristics, for example news, email, etc. Each category has associated update periods, priority characteristics, selective enable or disable parameters, and transmission repeats.

Web Servers
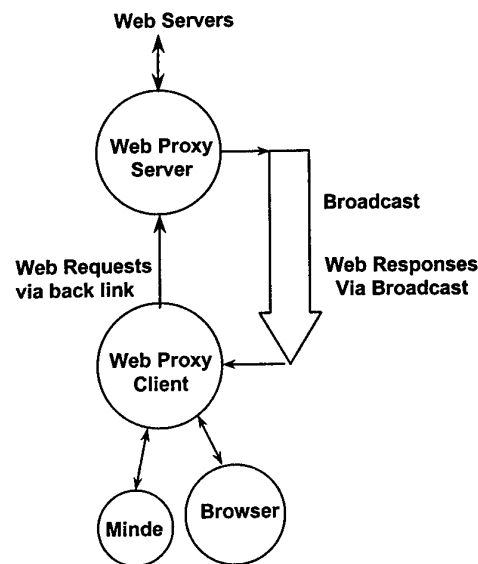
Figure 7. Schematic operation of the TBS web proxies.

(ii) Web Browsing

There is an increasing focus on web based systems for commercial information delivery and this is flowing through to military information systems. Also, many archives, databases, and image presentation packages, which were created with custom user interfaces, are implementing web front ends to facilitate network access and reduce user training requirements.

Conventional access to web servers requires a full duplex connection, which is not available on TBS. In cases where a web site is of significant importance to users, the entire site, or appropriate subsections, can be broadcast to the clients and served locally by the receive terminal web server. Commercial mirroring software and the automated TBS PUSH Service are used.

The TBS Web Proxy Service (Figure 7) was developed to provide an interactive web browsing facility assuming a narrow band request channel is available. The service incorporates a client proxy at the deployed receive site to terminate the user's browser connections and a server proxy at the broadcast centre, which connects to web servers in the strategic network to fulfil browsing requests. In operation, the user activates a link on a web page and the user's browser makes a connection to the client proxy which in turn transmits a request for the appropriate web page to the server proxy via the request link. The client proxy attaches user details and scheduling priorities to the request. On receiving the client request, the server proxy retains the user details and establishes a connection with the target web server to retrieve the requested page. The response is stored in a server cache and a request issued to the scheduler, coupled with the user's details and parameters provided with the original request. The file is transmitted by MUSTAFA under scheduler control and the client proxy delivers the response to the browser. The received file is also stored in local cache on the receive client. This series of operations is transparent to the user and appears only marginally slower than a fast fixed internet connection at light system loads. Loaded browsing performance is dependent on allocated

priorities and delivery times, but the TBS scheduler is given considerable license to attempt to deliver interactive services such as web browsing promptly, at the expense of automated downloads and other non interactive services. Maximal use is made of both server and client caching in an attempt to improve performance.

LAN based hosts at the receive site obtain web services by proxying their browsers to the TBS client. Requests from many users can be handled simultaneously. Users specify browsing parameters such as user name, password and scheduling priorities via a special browser window, known as the Minder Panel, implemented with a custom Java applet. The applet makes a connection to a client proxy to register users and their priority settings. The Minder Panel also makes a connection to a Client Manager software application to facilitate status reporting and system alerts.

(iii) E-mail

The TBS mail system is currently a commercial standard SMTP/POP3 system with directory replication over TBS. This could be replaced by a more secure X400 or Lotus Notes based system if desired.

SMTP server, client and POP server processes are run on a mail host at the broadcast centre. This handles all mail entering and leaving the TBS system from other networks. All management of user accounts and passwords is done from this central facility. Each deployed TBS receive client, runs similar POP and SMTP processes.

To provide downward mail service from the strategic domain to deployed users, the POP mail directories of the mail host are automatically broadcast by the TBS PUSH service. Usually, three or five minute updates are specified. Local users on a deployed LAN use a POP client such as Microsoft Outlook to automatically check their mailbox as often as desired. Because of the high downlink bandwidth available, mails with attachments hundreds of megabytes in size are easily handled.

To provide upward service, mail directed from deployed user mail clients is passed via SMTP to the SMTP server on the TBS Receive Client computer. If a TBS request link is currently connected, the deployed SMTP server immediately forwards the mail up to the SMTP client at the broadcast centre. If not, it queues the mail, polls every one minute for a request link connection, and forwards queued mail when possible. Actual mail capability from the deployed to the strategic domain is dependent on the request links used. Trials have shown that mail sizes of 100 kB are a reasonable practical limit using 2400 bps Optus Mobilesat request links.

This mail system has an important advantage over a simpler, conventional, ISP style, pure POP system operated from the broadcast centre. It allows deployed users on a local area network to send mail in the absence of a TBS request link. The mail passes only as far as the receive client until a request link is connected, but there is no requirement on distributed users to know when request links are operating, and the user is shielded from error messages resulting from attempting to send mail over nonexistent links.

(iii) Cheetah File Manager

In some cases, custom proxy interfaces incorporating additional functionality are required to service existing information systems over TBS. The example described here is that of the Cheetah map display application developed by Australian Defence Industries. This software places icons representing the locations of forces, platforms, military assets, etc, on a map background, and continually updates the display in real time from information supplied in small standard messages continually received from a Cheetah server.

The message service is usually provided to clients over narrow band serial links. To offer an improved Cheetah service over TBS, a Cheetah File Manager application was developed (Figure 8). A Cheetah server is configured to receive the message stream at the broadcast centre and output concatenated message data to a file. The Cheetah File Manager service reads this file and scans for updated tracks, storing these in a data base with associated date/time information. This database is used to periodically build a new output file containing details of the tracks which have been updated in a specified period. The application then automatically requests the TBS scheduler to deliver this file to clients over the broadcast. An update period of a few minutes is used. The file is automatically ingested by the deployed Cheetah client displaying the latest information. Field deployed terminals can thus obtain a complete picture immediately after switch on, rather than waiting for progressive delivery of a picture over narrow band links.
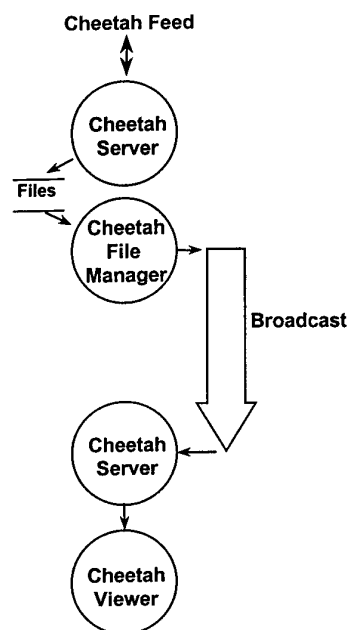
Figure 8. Schematic operation of Cheetah support over TBS

5. US GBS and Interoperability

The impetus for an Australian theatre broadcast system arose both from commercial developments and from similar developments in the US Department of Defense. In 1994 the US implemented the Joint Broadcast Service, which provided service to US forces deployed in the European theatre until 1999. Due to the success of this interim service, a Phase II program known as the Global Broadcast System (GBS) was pursued, with Raytheon Co as prime contractor. Fielding of the GBS system has commenced in the Pacific Theatre, although the system is still undergoing significant developmental changes.

The UK is currently in the process of defining a Direct Broadcast System (DBS) and building a demonstration system. The form DBS this will take has not been finalised.

Any decision to proceed with indigenous developments rather than purchase systems developed overseas involves considerations of interoperability, the extent to which the systems can be tailored to meet Australian requirements, sovereignty, access to system code, cost, logistics, Australian industry support, etc. At this stage, no decision has been made on what path should be taken towards a fully operational Australian high data rate broadcast capability. Allied interoperability remains however, an important concern for all Australian military communications, with the goal of seamless exchange of releasable information among all parties. Different degrees of interoperability may be achieved by a number of different approaches.

Direct reception of an allied channel or security compartment from the US GBS broadcast satellites would almost certainly require US GBS equipment supplied by the US contractor. It is unlikely that sufficient hardware and software specifications could be obtained to build a compatible system in the absence of a procurement. Procurement of a US GBS type transmit system and US receive technology would allow creation of a Australian GBS-like system using an Australian broadcast satellite. This may allow Australian forces to receive an allied channel from US satellites when appropriate. This would be possible only if the differences between the Australian and US GBS systems remained minimal. Some differences would be inevitable, due to differences between the Australian and US broadcast satellites, hardware and software upgrade schedules in both countries and differences in the system configuration Australia may adopt to support local requirements. Reception of the allied channel would occur at the expense of losing connectivity with the Australian system unless the allied channel was rebroadcast on the Australian satellite.

If a technology similar to the current DSTO developed TBS demonstration system is pursued, interoperability could be achieved by strategic exchange of releasable information using land line communications between the US and Australian PIPs, and uplinking the allied channel on both broadcast systems. Australian receivers would be unable to receive from the US GBS satellites and interoperability would be limited to the field of view of the Australian satellite unless additional commercial satellite bandwidth was procured.

6. Capability Enhancement with TBS

There are a number of significant challenges to be addressed if concrete capability enhancement is to result from application of high bandwidth information delivery systems in the Australian military environment. The effectiveness of such systems is critically reliant on information management infrastructure, in both strategic and deployed environments.

An integrated management approach needs to be developed in which broadcast or asymmetric technologies seamlessly integrate with available full duplex and low bandwidth communications. This is currently lacking. It should be possible for example, for automated agents to make decisions on the delivery paths for information, and appropriate bandwidth allocated for transmission. This requires an extensive metadata framework. Middleware management layers that perform some of these functions are under development by other agencies within the ADO and middleware interfaces have been developed for the TBS system by the EXC3ITE project. These interfaces enable applications resident elsewhere in the strategic network to communicate with the TBS scheduler and arrange for broadcast of traffic. Using this approach it should be possible to radically improve delivery effectiveness for existing mail systems, responses to database queries and image libraries for example.

The TBS system attempts to address quality of service issues though prioritisation of traffic and adherence to delivery deadlines, etc, but is only partially effective in delivering timely services to deployed users due to the lack of similar principles in the wider strategic network. Network wide, enterprise driven policies that can affect and enforce end-to-end military value by maximising military value on all links within the network need to be developed.

Organisational challenges are also created by widespread access to strategic information resources. Existing command and control structures often assume information is passed sequentially down the chain of command, and vetted at every stage, rather than pulled directly by the end user, bypassing the command chain. High bandwidth access has not been widely available in the past, so this issue has not been adequately addressed. One of the ways of restricting unfettered access is to prepare information support packages tailored to the requirements of specific users. These can be broadcast (PUSHed) or users granted permission to selectively PULL parts of them from the deployed domain. Tailored support packages also offer greater capability enhancement to users who are unable or unwilling to use request links frequently. The drawback is the considerable manpower required on the strategic side for package preparation and management and the difficulty of predicting information requirements in advance.

There are always new issues to be addressed in deploying any new military technology. Theatre Broadcast is no exception. However it is likely that the advantages offered by a cost effective, scalable, high data rate, information delivery service, and the prospect of its integration with information management applications, will be sufficiently attractive to ensure its ongoing use and further development.

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19. ABSTRACT
The Theatre Broadcast System is a DSTO developed Concept Technology Demonstator communications system comprising a high data rate satellite broadcast capability matched with low/ medium data rate request channels. The system has the potential to enhance the effectiveness of data dissemination to deployed forces in a cost effective manner. This document provides an overview of the system concept, the principles of operation and details of the initial implementation.